Evaluation of fermented cassava tuber wastes in broiler chickens feeding

S. O. Aro, J. O. Agbede[1], O. O. Dairo, E. Ogunsote, V. A. Aletor

Department of Animal Production and Health, the Federal University of Technology, Akure, Nigeria

SUMMARY

Two cassava tuber wastes (CTW): cassava peels and cassava starch residues were enriched through solid substrate fermentation using *Lactobacillus delbrueckii, Lactobacillus coryneformis* and *Aspergillus fumigatus*, a process which took the advantage of the lysine and linamarase secreting ability of the two lactic acid bacteria and cellulose degrading potential of the fungus. The enriched wastes were used to formulate broilers diets in which each was included at 0, 20, 40 and 60% in a completely randomized design in an 8-week trial. Three hundred and fifty (350) day old (Ross 308) broiler chicks were randomly allotted to 7 treatment diets at 10 chicks per replicate of five. The control diet contained no enriched CTW (0%) while diets 2–4 contained 20–60% microbially fermented cassava peel [MFCP], diets 5–7 contained 20–60% microbially fermented cassava starch residues [MFCSR]. Growth performance, blood variables, serum biochemistry and economy of production were the response criteria. The final body weight (1.20-1.48 kg) and weight gain (1.16-1.44 kg) and weight gain (1.16-1.44kg) were not significantly (P>0.05) affected. Total feed intake increased with increased MFCP inclusion but decreased with increasing level of MFCSR with bird fed control diet having the best FCR (2.56). Only the Mean Corpuscular Haemoglobin Concentration (MCHC) was not significantly (P>0.05) affected of all the blood haematological indices measured. Of the entire serum metabolites measured only the albumin and globulin were significantly (P<0.05) affected. The feed cost per kilogram body weight decreased by 27.3-39.4% when the CTW was included. However, within the limit of this study, the inclusion of 40% and 60% of MFCP (27.3% and 23.9% cost reduction, respectively), could lead to profitable broiler production in sub-Saharan Africa.

Keywords: Broilers, Cassava tuber wastes, cost benefit, growth indices

[1] Corresponding author e-mail: joagbede@yahoo.com

INTRODUCTION

The current focus of research in the so-called emerging economies is on mitigating the perennial high cost of feed ingredients which is the bane of the expansion of livestock industries. One of the suggested elixirs to the high cost of feed ingredients is the use of alternative feed ingredients which often come in form of agro-industrial wastes (Sucharita *et al.,* 1998; Aro, 2010).

Two of such wastes that are produced in large quantum in Nigeria are cassava peels and cassava starch residues (Aro *et al*., 2010c). The nutritional potentials of these two cassava tuber wastes (CTW) as substitutes to some energy-rich conventional ingredients like maize, guinea corn and millet in animals have been discussed (Antai and Mbongo, 1994). Inherent problems associated with the use of these unconventional feed ingredients such as their low protein and high fibre content coupled with their cyanide contents have necessitated the use of different adaptable methods of improving these ingredients for the use of farm animals. One of such methods is the use of a consortium of micro-organisms namely *Lactobacillus delbrueckii, Lactobacillus coryneformis* and *Aspergillus fumigatus* for protein/amino acids enrichment, crude fibre degradation and reduction of cyanide (Aro *et al.,* 2010b). This biotechnological approach has been used to upgrade the nutrient status of CTW such that an array of enhanced products like naturally fermented cassava peels (NFCP), naturally fermented cassava starch residues (NFCSR), microbially fermented cassava peels (MFCP) and microbially fermented cassava starch residues (MFCSR) have been developed (Aro *et al*., 2010a & b). These nutrient-enhanced CTW products have been used in pigs and rabbits feeding with promising results especially on the plane of performance parity with maize and drastic reduction in the cost of feeding and total cost of production.

The utilization of CTW products fermented with micro-organisms earlier mentioned, to our knowledge, has not been extended to broiler feeding. This study was therefore designed to assess the effect of feeding two of the CTW on performance and economy of production of broiler birds. Other response criteria measured included haematology and serum biochemistry of the experimental birds.

MATERIAL AND METHODS

Experimental Site, Experimental Animals and Experimental materials

The experiment was carried out at the Broiler Unit of the Teaching and Research Farm of the Federal University of Technology, Akure, Nigeria. Three-hundred and fifty (350) day old (Ross 308) broiler chicks were randomly assigned to the seven experimental diets at ten chicks per replicate of five for an eight week feeding trial. The brooding temperature varied from 35^{o}C at day old to 29^{o}C at 3rd week of age and kept at ≈25^{o}C thereafter. The chicks were placed on the experimental diets from the day of arrival. The birds were raised using common management practice for broilers. Cassava peels which were incorporated into the diet of the animals were obtained fresh from a cassava processing community located along Igbatoro road (a garri producing community), Akure, Ondo state and the cassava starch residues were obtained fresh from Matna Foods Limited; a cassava starch processing factory located at Ogbese, along Owo-Benin express road in Ondo state, Nigeria.

Production of fermented cassava wastes

The microbially fermented cassava peels and cassava starch residues were produced by the methods described by Aro (2010). The freshly collected cassava tuber wastes (cassava peels and cassava starch residues) were sun dried for three to five days depending on environmental temperature and the intensity of the sun. They were thereafter crushed to aid further processing, packed and stored in a cool place prior to inoculation with micro-organisms. Two different strains of lactic acid bacteria (*Lactobacillus delbrueckii* and *Lactobacillus coryneformis*) and a fungus (*Aspergillus fumigatus*) were isolated and cultured. Two kilogrammes (2 kg) of dried cassava peels were weighed into nylon bags and 1500 ml of sterile water were added, likewise 2 kg of cassava starch residues were weighed and 2000 ml of sterile water were added. The samples were then steam-heated for 30 minutes at 100^{o}C. The samples were allowed to cool after which they were emptied into fermentation trays overlaid with cellophane wrapper inside the lamina flow chamber. Each 2 kg sample was then inoculated with 15 ml each of *L. delbrueckii* and *L. coryneformis* containing 1.02 x 10^4 cells/ml, and 30 ml of *Aspergillus fumigatus* containing 1.07 x 10^7 spores/ml. The trays were then covered with cellophane wrapper and kept in fermentation chamber for five days under ambient temperature and controlled humidity ensured by the cellophane wrapper technique meant to maintain optimum water activity.

Experimental diets and animal management

Seven experimental diets were formulated and used for the trial. Six of the diets had CTW inclusions while the remaining one without CTW inclusion serves as the control diet. Three of the CTW-based diets had microbially fermented cassava peels (MFCP) included at 20%, 40% and 60% while the remaining three CTW-based diets had microbially fermented cassava starch residues (MFCSR) included at 20%, 40% and 60% at both starter and finisher phases (Tables 1 & 2). On analysis the MFCP contained moisture content: 4.63%, crude protein: 8.94%, crude fibre: 34.25 g, ash: 4.15 g, ether extract: 3.12 g and NFE: 44.91 g/100g while MFCSR contained moisture content: 3.66 g, crude protein: 7.00 g, crude fibre: 14.77 g, ash: 3.04 g, ether extract: 3.97 g and NFE: 67.56 g/100g.

Table 1: Gross Composition (g/100g) of Experimental Diets (Starter feed)

Ingredients	Control	MFCP 20%	MFCP 40%	MFCP 60%	MFCSR 20%	MFCSR 40%	MFCSR 60%
Maize	49.00	32.00	19.85	4.00	36.00	10.60	-
MFCP	-	20.00	40.00	60.00	-	-	-
MFCSR	-	-	-	-	20.00	40.00	60.00
PKC	5.00	-	-	-	-	-	-
GNC	20.50	23.80	19.85	20.00	18.50	31.20	21.50
SBM	15.00	12.00	10.20	7.80	15.00	12.00	10.00
Wheat offal	3.00	5.00	3.90	-	3.00	-	-
Fish meal	2.00	2.00	2.00	5.00	2.00	3.00	6.00
Bone meal	2.30	2.30	2.64	1.30	2.30	1.50	1.00
Limestone	2.50	2.20	0.84	1.20	2.50	1.00	0.80
*Others	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated							
ME (MJ/kg)	11.79	11.93	11.89	11.88	11.95	11.89	11.94
CP (%)	23.08	22.60	22.69	22.80	22.30	22.84	22.15
CF (%)	3.55	4.19	4.78	5.16	4.11	9.00	9.00

*Other included salt 0.25 g, premix 0.25 g, lysine 0.10 g and methionine 0.10 g/100 g. GNC = Groundnut Cake; SBM = Soya bean meal; BDG = Brewers Dried Grain; MFCP = Microbially Fermented Cassava Peels; MFCSR = Microbially Fermented Cassava Starch Residues

The day old broiler chicks were randomly allotted to each of the seven treatment diets at 10 birds of mixed sexes per replicate with each treatment comprising five replicates in a completely randomized design. The feeding trial lasted for 8 weeks and the birds were fed their respective experimental diet *ad libitum* throughout the period. The criteria of response included performance indices, haematological and serum biochemical indices and economy of production. At age 8 week, 5 birds per replicate were randomly selected and slaughtered. The blood was then allowed to flow freely into sample bottles containing a few mg of Ethylene diaminetetraacetic acid (EDTA) and also into clean centrifuge test tubes. The samples in the bottles containing EDTA were subsequently processed for haematological studies. The packed cell volume (PCV) was estimated by spinning about 75µl of each blood sample in heparinised capillary tubes in a haematocrit microcentrifuge for 5 min, and the total red blood cell (RBC) was determined as described by Lamb (1981). The haemoglobin concentration (Hbc) was estimated using the cyano-methemoglobin concentration method. The mean cellular haemoglobin concentration (MCHC), mean cellular haemoglobin (MCH) and mean cell volume (MCV) were also calculated as described by Lamb (1981). The samples in the test tubes without EDTA were allowed to coagulate for about 6 h. The serum was separated into sterile universal bottles and kept deep-frozen at -18°C prior to its analysis for serum biochemical indices. The serum Aspartate aminotransferase (AST), Alanine aminotransferase (ALT),Total protein (TP), Globulin, Albumin, Glucose and Cholesterol were estimated using diagnostic kits (Randox Laboratories Ltd, UK test kits).

Table 2: Gross Composition (g/100g) of Experimental Diets (Finisher Phase)

Ingredients	Control	MFCP 20%	MFCP 40%	MFCP 60%	MFCSR 20%	MFCSR 40%	MFCSR 60%
Maize	54.25	37.75	22.20	-	36.00	20.00	-
MFCP	-	20.00	40.00	60.00	-	-	-
MFCSR	-	-	-	-	20.00	40.00	60.00
GNC	15.00	15.00	-	-	15.00	14.00	12.75
SBM	12.55	12.30	29.55	20.55	13.75	20.75	17.00
Wheat offal	13.00	10.00	3.00	11.20	10.00	-	4.00
Fish meal	2.00	2.00	2.00	3.00	2.00	2.00	3.00
*Others	3.2	3.2	3.2	3.2	3.2	3.2	3.2
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated							
ME (MJ/kg)	11.97	11.99	12.00	11.99	11.90	11.99	11.99
CP (%)	20.10	20.31	20.52	20.25	19.96	20.74	20.35
CF (%)	5.35	5.56	5.38	7.30	6.85	7.33	9.91

*others are Bone meal 1.50 g, limestone 1.00 g, salt 0.25 g, premix 0.25 g, lysine 0.10 g and methionine 0.10 g/100 g. GNC = Groundnut Cake; SBM = Soya bean meal; BDG = Brewers Dried Grain; MFCP = Microbially Fermented Cassava Peels; MFCSR = Microbially Fermented Cassava Starch Residues

The economy of production and cost of feed were calculated based on the prevailing prices ($ = ₦162). All other costs which were common to the experimentation were ignored. Thus various costs were calculated accordingly. The cost of feed consumed = cost of 1 kg of feed x total feed consumed. Feed cost/kg body weight = cost of feed consumed/final body weight of birds fed the diet. Cost of feed/gain = cost of feed/kg x feed conversion ratio. Gross profit = sales or revenue – total cost of production.

Statistical Analysis

Data collected were subjected to statistical analysis using analysis of variance (ANOVA) of SPSS 17 (2008) package. The significant treatment means were compared using the Duncan option of the same software.

Table 3: Performance of broiler birds fed microbially fermented cassava tuber waste-based diets

Indices	T1	T2	T3	T4	T5	T6	T7	±SEM
IW g/b	44.12	47.06	46.08	48.04	48.04	49.02	48.04	0.47
FW kg/b	1.48	1.28	1.40	1.41	1.31	1.31	1.20	0.42
TWG kg/b	1.44	1.23	1.35	1.39	1.27	1.26	1.16	0.43
AWG g/b	25.64	21.93	24.12	24.26	22.59	22.58	20.63	0.76
TFI kg/b	3.66^{cd}	3.95^{bc}	4.58^{ab}	4.82^{a}	3.77^{cd}	3.22^{cd}	3.12^{d}	0.15
AFI g/b	65.28^{cd}	70.37^{bc}	81.84^{ab}	86.11^{a}	67.33^{cd}	57.57^{cd}	55.63^{d}	2.68
FCR	2.56^{c}	3.21^{a}	3.41^{a}	3.73^{a}	3.01^{b}	2.63^{c}	2.79^{b}	0.15
% Mortality	14.00^{a}	4.00^{b}	25.33^{a}	19.67^{a}	13.67^{a}	14.00^{a}	20.00^{a}	2.84

a-d = Means on the row but with different superscripts are statistically (P<0.05) significant. T1 = Control diet; T2 = Diet with 20%; T3 = Diet with 40% MFCP; T4 = Diet with 60% MFCP T5 = Diet with 20% MFCSR; T6 = Diet with 40% MFCSR; T7 = Diet with 60% MFCSR; MFCP= Microbially fermented cassava peels; MFCSR = Microbially fermented cassava starch residues. IW = Initial weight; FW = final weight; AWG = average weight gain; TFI = total feed intake; AFI = average feed intake; FCR = feed conversion ratio

RESULTS AND DISCUSSION

Table 3 showed that the Final body weight (FBW), Total weight gain (TWG) and average weight gain (AWG) of birds fed the control diet were not significantly (p>0.05) different from those fed the test diets. However, birds fed on the control diet was numerically highest in FBW(1.48 kg/bird) than those fed the test diets (1.40 – 1.20 kg/bird) with numerical increase percent of 4.73 – 13.51 on birds fed microbially fermented cassava peels (MFCP) and 11.49 – 18.92 on birds fed on microbially fermented cassava starch residues (MFCSR). Similar trends were observed for TWG and AWG. This thus suggests the inadequacy or otherwise of the fermentation technique (especially in relation to crude fibre degradation) used to improve the nutritive quality of the two cassava tuber wastes and their efficient utilization for growth enhancement by the birds. Ademola *et al*. (2009) reported similar decrease in weight of broilers fed dietary inclusion of garlic and ginger as anti-lipidemic agents in the diets. On the other hand the Total feed intake (TFI) and average feed intake (AFI) of the birds were significantly (p<0.05) affected by the dietary treatments (Table 3). The trend of observation was an increase in feed intake with increase in the dietary level of microbially fermented cassava peels (MFCP) while the converse held true for the microbially fermented cassava starch residues (MFCSR). The reason for the differential feed intake between the two cassava tuber wastes could be as a result of their palatability as earlier confirmed by Aro *et al*. (2010b**)** that fermented cassava peels are more palatable than fermented cassava starch residues as adjudged by their voluntary intake. The feed conversion ratio (FCR) was best (2.56) in birds fed on the control and poorest (3.73) in birds that consumed 60% MFCP diet in which the highest feed intake was recorded. In most cases, birds fed on microbially fermented-based diets consumed more feed than those fed the control diet but utilized the diets poorly. This could have been as a result of the inadequacy of the fermentation technique to degrade the crude fibre components of the CTW to a tolerable level in the diets and this is consistent with the earlier report by Aro *et al*. (2010c). The highest mortality (4.33 birds/treatment) and percentage mortality (25.33 birds/treatment) were recorded in the 40% MFCP group while the lowest (0.67 birds/treatment and 4.00%) were observed in the 20% MFCP group (Table 3). The reason for the high mortality in birds fed on 40% MFCP-based diet could not be readily provided as mortality however seemed not to be influenced by the applied dietary treatments.

Table 4: Economy of production of broiler birds fed microbially fermented cassava tuber waste-based diets

Indices	T1	T2	T3	T4	T5	T6	T7	±SEM
FW kg	1.48	1.28	1.40	1.41	1.31	1.31	1.20	0.42
TWG kg	1.44	1.23	1.35	1.39	1.27	1.26	1.16	0.43
TFI kg	3.66^{cd}	3.95^{bc}	4.58^{ab}	4.82^{a}	3.77^{cd}	3.22^{cd}	3.12^{d}	0.15
Cost of feed consumed ₦	15.07^{a}	12.50^{b}	10.33^{bc}	10.44^{bc}	11.76^{bc}	9.53^{c}	7.22^{d}	90.11
Feed cost/kg body weight ₦	1.02^{a}	0.98^{a}	0.74^{ab}	0.78^{ab}	0.90^{ab}	0.76^{ab}	0.62^{ab}	7.04
Cost of feed/gain ₦	1.08^{a}	1.05^{a}	0.88^{ab}	0.83^{ab}	0.97^{ab}	0.81^{ab}	0.67^{b}	7.60
Gross profit ₦	27.61^{a}	17.63^{d}	27.21^{a}	27.72^{a}	20.63^{c}	22.86^{bc}	18.39^{d}	45.23

T1 = Control diet; T2 = Diet with 20% MFCP; T3 = Diet with 40% MFCP; T4 = Diet with 60% MFCP T5 = Diet with 20% MFCSR; T6 = Diet with 40% MFCSR; T7 = Diet with 60% MFCSR; MFCP= Microbially fermented cassava peels; MFCSR = Microbially fermented cassava starch residues. US Dollar = ₦162

The economy of production (Table 4) revealed that the cost of feed consumed, cost per kilogram of feed, feed cost/kilogram body weight and cost of feed/gain were significantly affected by the dietary treatments. These cost indicators were highest in the control group and lowest in the 60% MFCSR group, which suggests plausible economic benefit of this inclusion level in broiler production. Generally, the inclusion of the two microbially fermented cassava tuber wastes lowered the cost of feed and total cost of production but with a concomitant decline in the final weight of the birds when compared with the control (Table 3). Observably, the cost reduction was more in the MFCSR diets than in the MFCP diets due to more feed consumption in the latter. This significant reduction in the cost of production informed Sucharita *et al.* (1998) to suggest that research focus in the developing economies should be channelled towards the utilization of the unconventional feed sources as a way of revolutionizing the livestock industry in such regions. The highest gross profit per 10 birds/treatment ($27.72) was obtained in birds fed 60% MFCP diet while the lowest ($17.63) was recorded on birds fed 20% MFCP diet. Similar cost reductions have been previously reported when pigs were fed on fermented cassava tuber wastes (Aro *et al.,* 2010b).

Table 5: Haematological indices of broilers fed dietary inclusion of microbially fermented cassava tuber wastes

Indices	Control	MFCP 20%	MFCP 40%	MFCP 60%	MFCSR 20%	MFCSR 40%	MFCSR 60%	±SEM
PCV %	27.78^{ab}	28.11^{ab}	28.78^{a}	28.89^{a}	26.00^{b}	26.56^{ab}	27.00^{ab}	0.30
RBC$10^{6}mm^{-3}$	2.16^{ab}	2.16^{ab}	2.26^{a}	2.28^{a}	1.84^{b}	1.96^{ab}	2.01^{ab}	0.05
HB g/dl	9.27^{ab}	9.36^{ab}	9.60^{a}	9.61^{a}	8.67^{b}	8.86^{ab}	8.99^{ab}	0.10
MCV μ^{3}	128.97^{b}	131.86^{ab}	128.33^{b}	127.66^{b}	146.15^{a}	139.42^{ab}	137.52^{ab}	2.08
MCHC %	33.36	33.28	33.36	33.26	33.33	33.35	33.29	0.01
MCH pg	43.03^{b}	43.87^{ab}	42.82^{b}	42.47^{b}	48.71^{b}	46.50^{ab}	45.77^{ab}	0.69

Values are for 25 birds/diet; a-b = Means within the same row but with different superscripts are statistically (P<0.05) significant. PCV=Packed Cell Volume; RBC=Red cell count; HB=Hemoglobin estimate; MCV=Mean Cell Volume; MCH=Mean Cell Hemoglobin; MCHC=Mean Cell Hemoglobin Concentration

The response of the birds showed that all the haematological parameters measured except Mean Corpuscular Haemoglobin Concentration (MCHC) were significantly (p<0.05) influenced by the dietary treatments (Table 5). The packed cell volume (PCV), red blood corpuscles (RBC) and hemoglobin concentration (Hb) increased with increase in dietary levels of the CTW inclusion. All these values with the exception of the RBC of birds fed 20% and 40% MFCSR improved towards the normal range of 2.5-3.5 x 10^{6} mm^{-3} (Jain, 1993). Thus birds fed fermented cassava peels in most cases have better hematopoietic capabilities than those fed the control diet and those fed the MFCSR-based diets: a vivid manifestation of their safe incorporation into broilers diets at levels used under this study. Such improved PCV and Hb was observed in broilers fed *Lablab purpureus* beans-based diets (Abeke *et al.*, 2009). The mean corpuscular volume (MCV) ranged between 127.66 μ^{3} in the 60% MFCP group to 146.15 μ^{3} in 20% MFCSR group. Birds fed MFCSR diets had bigger red blood cells than those fed on the control and MFCP diets. This would have resulted from a physiological adjustment of their relatively fewer red blood cells to carry more oxygen for respiratory activities. This could also explain the reason for their relatively higher values of mean corpuscular haemoglobin (MCH) thus concentrating more of the respiratory pigment (haemoglobin) to probably combat tissue hypoxia caused by circulating residual cyanide in their blood (Guyton and Hall, 1996; Berg *et al.,* 2002).

Table 6: Serum Biochemistry of Broilers Fed Dietary Inclusion of Microbially Fermented Cassava tuber wastes

Parameters	Control	MFCP 20%	MFCP 40%	MFCP	MFCSR 20%	MFCSR 40%	MFCSR 60%	±SEM
Glucose (mg/dl)	277.67	241	250.67	212.00	255.00	270.67	241.33	8.75
Chol (g/l)	197.60	194.17	193.05	199.76	209.74	190.73	200.64	3.58
Alb (g/dl)	4.49[ab]	4.68[a]	4.14[b]	4.51[ab]	4.58[a]	4.49[ab]	4.58[a]	0.53
Glb (gd/l)	0.37[ab]	0.56[ab]	0.83[a]	0.43[ab]	0.16[b]	0.32[ab]	0.72[ab]	0.08
TP (g/dl)	4.86	5.24	4.97	4.94	4.74	4.81	5.30	0.09
AST (U/l)	47.00	60.67	59.67	48.33	35.33	44.33	55.67	3.86
ALT (U/l)	12.67	7.33	10.67	11.33	12.67	9.00	13.00	0.69

Values are for 25 birds/diet. a-b = Means within the same row but with different superscripts are statistically (P<0.05) significant. TP = Total protein; Chol = Cholesterol; Alb = Albumin; Glb = Globulin; AST = aspartate aminotransferase; ALT = alanine aminotransferase

The serum biochemical values (Table 6) showed that glucose, cholesterol, total protein, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were not significantly affected by the dietary treatments. The blood glucose level of the birds ranged between 212 mg/dl in the 60% MFCP diet to 277.67 mg/dl in the control diet. An initial increase in blood glucose was observed in both the MFCP and MFCSR diets from 20 to 40% inclusion levels, followed by a decline at 60% level, also there was an inverse relationship between blood glucose and cholesterol concentration in birds fed CTW diets. The fact that values obtained for both glucose and cholesterol concentration did not differ significantly among treatment means showed that the utilization of the CTW in the diets of broiler birds will have no detrimental effects on their physiological functions and probably meat quality. The total protein (TP) content of the serum were statistically similar among dietary treatments ranging from 4.74 g/dl in the 20% MFCSR group to 5.30 g/dl in the 60% MFCSR group. The general trend of observation was a linear decrease in TP with dietary increase in the level of MFCP and a linear increase with increase in the level of MFCSR in the diets. The TP values obtained under this study were within the range of 4.68 and 5.27 g/dl reported by Abeke *et al.* (2009) for broiler finishers fed graded levels of *Lablab purpureus* beans and Ayoola *et al.* (2010) on graded levels of *Telfaria occidentalis* leaf extract. The level of serum albumin and globulin, though statistically significant among the treatment means were all comparable to those of the control and did not follow a particular trend. The levels of aspartate aminotransferase (AST) and alanine aminotransferase (ALT) did not vary significantly among the dietary treatments. These two enzymes are biomarkers for tissue damage and hepatic degeneration (Agbede *et al.*, 2011). A general decline in the level of the two enzymes was observed with the inclusion of MFCP in the diets while a slight increase observed with 60% inclusion of 60% MFCSR was still within the ambit of statistical insignificance relative to the control. Since significant elevation of these enzymes in blood serum is indicative of serious tissue and hepatic damage, these CTW could therefore be adjudged safe at the levels at which they were incorporated into the diets. Even the highest level of ALT (13.00 U/l) obtained under this study was still within the normal blood range of 1-37 U/l reported by *Ker et al.* (1982) for chickens.

CONCLUSIONS

From the foregoing, even though the final weight and total weight gain of the broilers were not significantly affected by the dietary treatments, the FW of birds fed the test diets were lower (4.73-13.51% MFCP group and 11.49-18.92% MFCSR group) than those fed the control diet indicating the possible inadequacy of the microbial fermentation technique used in this study. The values obtained for both haematological and serum variables suggest that the utilization of the CTW in the diets of broiler birds will have no detrimental effects on their physiological functions and thus could be considered safe within the limit of this study. Generally, the inclusion of the two microbially fermented cassava tuber wastes lowered the cost of feed and total cost of production but not without a concomitant decline in the final weight of the birds when compared with the control. In the main, only 40 and 60% MFCP could be considered as economically viable inclusion levels of these fermented wastes in broiler diets.

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